DOCUMENT RESUME

ED 172 634 HE 011 369

AUTHOR Lyell, Edward H.
TITLE The Cost Structure of Higher Education: Implications for Governmental Policy in Steady State.
PUB DATE 12 Apr 79
NOTE 71p.; Paper presented at the Annual Meeting of the American Educational Research Association (San Francisco, California, April 8-12, 1979)

EDRS PRICE MF01/PC03 Plus Postage.
DESCRIPTORS *Budgeting; Decision Making; Educational Finance; Enrollment Rate; Estimated Costs; Expenditures; *Higher Education; Models; Needs Assessment; Personnel Policy; Policy Formation; Public Education; Research Projects; *Resource Allocations; Retrenchment; *State Colleges
IDENTIFIERS *Colorado; University of Colorado Boulder

ABSTRACT

The historical pattern of resource allocation in American higher education as exemplified by public colleges in Colorado was examined. The reliance upon average cost information in making resource allocation decisions was critiqued for the special problems that arise from student enrollment decline or steady state. A model of resource allocation for institutional and interinstitutional decision making was designed based on the separation of expenditures into fixed and variable cost components. Measures for full costing, including partial opportunity cost accounting were incorporated into the model. The University of Colorado at Boulder was used to examine the cost structure in terms of average, marginal, variable, and fixed cost elements. The change in this cost structure was examined for a five-year period as personnel policies and enrollment changes were stimulated. Specific hypotheses were posited and tested. Results indicate areas of policy change and extensions for further research. It is concluded that a decrease in student number cannot be accommodated with the same policies as the growth period. A bibliography is included. (Author/SW)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED172634

The Cost Structure of Higher Education: Implications for Governmental Policy in Steady State.

by

Edward H. Lyell

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Edward Lyell

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) AND USERS OF THE ERIC SYSTEM."

Edward H. Lyell
Graduate School of Public Affairs
University of Colorado, Boulder 80309

Session Title: 10.21 Aspects of Costs and Educational Finance. ID #A-40

Presented at the
1979 Annual Conference
of the American Education
Research Association meeting
April, 1979, San Francisco, Cal.

HE 011 369

TABLE OF CONTENTS

	page
PURPOSE	1
BACKGROUND	2
METHODOLOGY	13
RESULTS	20
IMPLICATIONS FOR HIGHER EDUCATION POLICY	34
POTENTIAL EXTENSIONS OF THIS STUDY	49
BIBLIOGRAPHY	54

PURPOSE

This paper examines the historical pattern of resource allocation in American higher education as exemplified by public colleges in Colorado. The reliance upon average cost information in making resource allocation decisions is critiqued for the special problems which arise from student enrollment declin or steady state.

A model of resource allocation for institutional and inter-institutional decision making was designed based on the separation of expenditures into fixed and variable cost components. Measures for full costing, including partial opportunity cost accounting were incorporated into the model. For the purpose of this thesis one institution, University of Colorado - Boulder, was used to examine the cost structure in terms of average, marginal, variable, and fixed cost elements. The change in this cost structure was examined for a five year period as personnel policies and enrollment changes were simulated.

Specific hypothesis were posited and tested with the results indicating areas of policy change and extensions for further research.

The fundamental concern was substantiated that a decrease in student number cannot be accommodated with the same policies as the growth period.

BACKGROUND

American higher education is a leading expenditure of each state's government. For example, Colorado higher education has represented 27.5 percent of the states total budget of over one billion dollars. Higher education is 21.9 percent of the state's General Fund expenditures (JBC - 1976). Most members of the legislature are college graduates and frequently have advanced college degrees causing the legislature, and in particular the members of the Joint Budget Committee, to bring into the review process a great degree of knowledge and expressed interest. Colorado has developed and for several years used a very detailed budgeting system for higher education. The budget system has reflected the desire of budget analysts to conduct budget analysis at the lowest common denominator. The system is very detailed containing thousands of data elements for each major institution. This detailed budgeting system also reflects the anxiety of funders over the inability of higher education to link outcome or performance information with expenditures, and the resultant inability to measure system productivity.

Lyman Glenny, a leading researcher in higher education finance has said, "the state government remains the chief source of funding for higher education and nothing on the horizon would appear to change that observation for the future." (NACUBO, p. 2) Glenny goes on in this address and subsequent article (to college administrators),

> "..., the state is confronted with serious policy issues relating to support of research, public service and adult education, to falling enrollments in some public institutions, to the probable closure of some private liberal arts colleges and perhaps some public ones, to the continuing over supply of doctoral graduates, to competition with the collegiate sector of new forms and new institutions offering postsecondary education, and to a host of issues relating to finance in a period of high inflation and severe recession." (NACUBO, p. 4)

Meanwhile, the Colorado Commission on Higher Education (CCHE), brought together over 100 of Colorado's business, government, union, and political leaders to form eight task forces which met for 18 months to develop long range policy for Colorado higher education. Two major factors were discussed by a majority of the task forces; one, that demographic shifts will cause college enrollment to decline or reach steady state, even in Colorado; and two, that while the cost of higher education keeps going up the willingness of taxpayers to support higher education relative to other state activities is decreasing. Dr. William Adrian, then Deputy Director of CCHE has summarized these points as follows:

> Enrollment:
> "...although Colorado is in a more advantageous position than most states, prospects for continued growth in the system throughout the 1980's are not good. The future will be marked by fluctuations among programs and institutions and agonizing trade-offs in adapting to, at best, a limited growth environment for the State as a whole. Several Colorado colleges and universities are already learning to cope with a 'no-growth' environment including those universities which have been 'capped' and selected rural institutions which have reached an enrollment plateau. Most institutions are either at or close to their expected targeted enrollments. Institutional administrators will have to make difficult decisions in reallocating resources among programs, and likewise, the State must grapple with the same problem among institutions." (Adrian, 1976, p. 10)

Financing:

"The loss of public confidence in education is reflected not only in Gallup-type polls, but in increasing public reluctance to continue to support education as it has in the past. Higher education has lost ground as a major national and state priority. It is no longer exempt from careful scrutiny as it finds itself in stiff competition with other state and national needs. A study by Lyman Glenny at the Center for Research and Development in Higher Education at Berkeley, reported that the proportion of state general revenue going to higher education has dropped steadily since 1968 in the Midwest and since 1971 nationally. Colorado has also experienced a decline in proportion of state financial assistance to higher education." (op. cit., p. 14)

As higher education is in a period of economic constraints and leveling enrollments, it is imperative that decisions be made with full understanding of the costs of adding or subtracting numbers of students. Information on cost structure should assist decision-makers at the institution and state levels in preparing for the eventuality or possibility of what Kenneth Boulding has called the "creative management of decline." (Boulding, 1974) It has become necessary to address questions such as the following: How many dollars are necessary for an additional hundred students at a certain institution? Can these dollars be taken from an institution which has had an enrollment decline? What is the level of resources which can be taken from one program or institution and redirected to another without violation of contractual obligations or personnel rules. In spite of great efforts to develop planning models, costing models, and average cost information, there is no work that has adequately addressed the effects of higher education cost structure upon changing inputs and outputs of that system.

More important to higher education cost analysis is the historical behavior of institutional management in deploying its resources between fixed and variable costs.

Budget Procedure - Average Cost

In a grants economy it is difficult to link outcome or product to the cost of production (Boulding, 1973). Such is the case with higher education. In some functions higher education is within the exchange economy since identifiable products exist. However, these areas are usually the support functions, or auxiliary enterprises such as the dormitories, football teams, recreation centers, etc. The identification of specific product for instruction, or basic non-sponsored research is not well accepted. Thus the criteria for expenditure evaluation rests with the judgement of budgeting professionals. Without an explicit agreement on outcome or product for the major activities, budget analysts stress expenditure control. In higher education the fundamental cost to control is personnel cost, and faculty cost in particular.

Faculty cost is primarily dependent upon the number of faculty which exist. The student-faculty ratio becomes the primary tool for analysis. A slight upward change can bring delight to the cost accountant and fear of educational quality collapse to the academic. Historically, both sides have accepted the immaculate conception of the student faculty ratio since it varies little for a school once established and beyond a critical mass threshold of about 400 students. The student-faculty ratio's importance to higher education budgeting is but one example of the dependence upon

analytical ratios of input resources used in governmental resource allocation. In other areas of governmental service resource allocation is based on the number of cases per caseworker, or beds per doctor, or prisoners per guard, etc., most are average cost based.

Since the primary cost of higher education is faculty salary we expect that a long term dependence upon the student faculty ratio will lead to stability in average costs. Our expectation of a stable annual cost extends beyond faculty cost since many other expenditures are based on ratios of student number, quantity of product. The number of staff are dependent upon student number, as are number of library workers, administrators, student counselors etc. In higher education budgeting most expenditures are dependent upon a series of these ratios and in many states the budgeting process is based entirely on formulas which are dependent upon the number of students. (Glenny, 1976) Even our facilities are dependent upon student numbers. The average student is categorized by the courses taken, and each course has a facility demand based on historical utilization. The number of student spaces required is determined and a normative based utilization factor is assigned to weight the student stations needed. A laboratory may only be expected to achieve a 40 percent utilization of student spaces during a specified time period. Given those normative based ratios the institution develops a proposal for facilities needed which is accepted by the budgeting review groups all the way up the funding process to the governor or legislature, as long as the normative based utilization factors are met.

Thus in almost every way, from student-faculty ratio, to books per student by program, to support staff per faculty, or student, resource need in higher education is developed based on average cost formulas. It follows that the average cost per student should be a linear function over time.

As figure one shows for our example institution, the University of Colorado at Boulder, the average cost curve is almost linear, but it is not stable. During the period of rapid growth, from 1955 to 1967 the average cost per student increased, even in constant 1972 dollars. During its period of rapid growth the University of Colorado did not exhibit economies of scale, nor even of cost containment over time. Figure two shows that the average cost per student increased in both current and constant dollars. Since this is a picture of cost per student as student population increases, although occurring over time, the real dollar increase demonstrates the lack of an economy of scale in the system, and of the long term stability in the increase of per student average cost.

The third line on the long run average cost curve graph (Figure 1) illustrates the national trend of increasing average cost. The Carnegie Commission study on costing also used real dollar costs to illustrate that the educational system in general did not illustrate any economies of scale, actually increasing average cost in real dollars during a period of rapid growth or exhibiting dis-economies of scale (Carnegie, 1974, p. 25).

Both figure one and two show the cost curves of an institution during a period of rapid growth, and also during a period of steady state enrollment since the legislature has capped CU-Boulder at

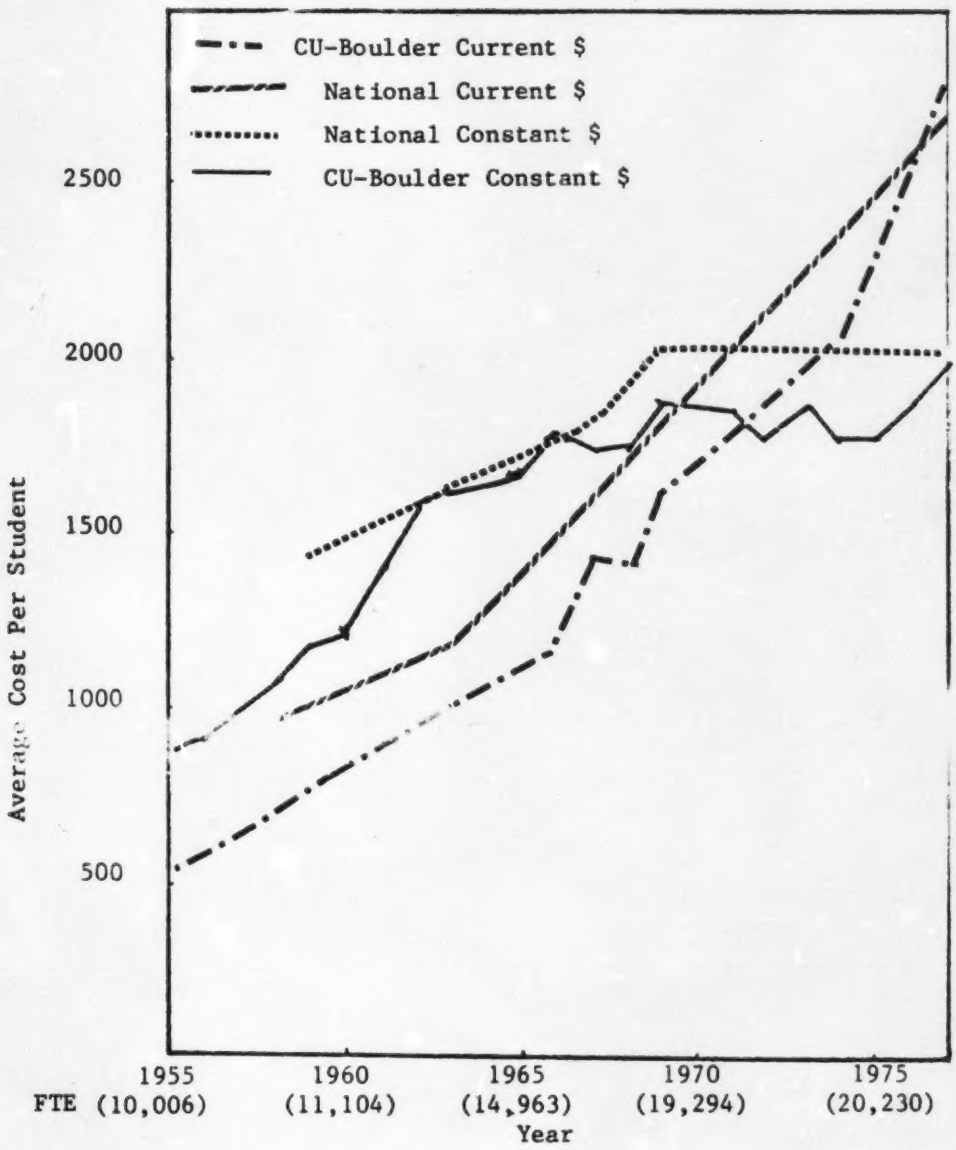

Figure 1. Long Run Average Cost - Average Cost Per Student

TABLE 1

LONG RUN AVERAGE COST

Year	No. of Students	Current Dollar (Average Cost) CU-Boulder	Current Dollar (Average Cost) National	Price Deflator	Constant Dollar (Average Cost) CU-Boulder	Constant Dollar (Average Cost) National
1955-56[1]	10,006	542		60.9	890	
1956-57[1]	10,647	575		62.8	916	
1957-58[1]	10,995	653		65.	1005	
1958-59[2]	11,104	710		66.	1076	
1959-60[2]	10,973	787	1007	67.5	1166	1492
1960-61[2]	11,493	834		68.6	1216	
1961-62[6]	12,083	941		69.2	1360	
1962-63[6]	12,266	1127		70.5	1399	
1963-64[6]	12,538	1175	1173	71.6	1641	1638
1964-65[6]	13,380	1191		72.7	1638	
1965-66[6]	14,693	1242		74.3	1672	
1966-67[6]	15,681	1358	1411	76.8	1768	1837
1967-68[6]	16,877	1428		79.0	1808	
1968-69[6]	18,217	1434		82.6	1736	
1969-70[6]	18,882	1638	1772	86.8	1887	2041
1970-71[6]	19,294	1702	1853	91.4	1862	2027
1971-72[6]	19,957	1777	1940	96.1	1869	2019
1972-73[6]	20,475	1776	2016	100.0	1776	2016
1973-74[6]	20,000	1986	2137	106.0	1874	
1974-75[6]	20,232	2079	2338	116.6	1783	2005
1975-76[6]	20,230	2276	2588	127.3	1788	2033
1976-77[3]	20,300	2476	2735	133.	1862	2056
1977-78	20,300	2802	2927	140.	2001	2090

able 1 (continued)

- Nov. 1958 Audit of Budget exclude cont. educ.
- Dec. 1963 Audit of Budget exclude cont. educ.
- Budget Request Document
- Budget Request Document
- GNP implicit price deflator
- Annual Appropriations Report, JBC
- Gross Domestic Product deflation, 1976
  Econ. Rep. President, p. 192
- National data from Table 5, page 35, Carnegie, 1972

  1971-75 data derived from inflation 1969-70. National data according to the Higher Education Price Index (Halstead, 1976)

20,000 FTE students for several years.

This phenomena should not surprise anyone since we have already demonstrated that the primary methods for allocating resources are all based on an average cost expenditure per student.

During the period of growth higher education institutions were successful in getting resource allocators, legislatures and governors, to accept as funding basis the student faculty ratio, and resulting average number of staff per full time equivalent student concept. Thus if the student-faculty ratio was 20:1 then the marginal cost of adding one hundred students was the cost of adding five faculty. Associated with the five faculty would be a specified number of support staff, supplies, facilities, etc., all based on relatively stable ratios to each other. In some ways the entire system was built on a tautological basis.

Such a funding basis would have resulted in a constant real dollar average cost if it were not for the labor intensity of the industry. Since higher education is almost eighty percent labor expenditure (Halstead, p. 136), and since labor prices have risen higher than general expenditures (until 1974) the adjustment for real dollars illustrates the overall upward bias of higher education total cost, and resultant average cost, to increase at a greater rate than inflation. Thus the increasing level of average cost (Hagstead, 1976)

It is apparent that the average cost has also been assumed to be equal to average variable cost, and any consideration for fixed costs has been ignored. Only in institutions of very small size, under 500 students have resource allocators acknowledged a

feeling for critical mass.

> "Among all groups of institutions, exceptionally small colleges and universities tend to have relatively high costs. The cost per FTE student declines quite sharply as institutions increase in size from very small levels to moderate levels, after which the decline occurs at a diminishing rate or levels off." (Carnegie, 1972,p,164)

We can conclude that the state resource allocators, executive and legislative analysts have accepted the institutional argument that student faculty ratio is crucial to production. What has followed is a long history of funding based on average cost per student.

Futher information on the financial crises in higher education can be found in most recent literature about higher education and the reader is referred to the works identified in the bibliography as well as the author's own doctoral thesis, especially for discussion of the many other policy issues arising from financial crises including governance confusion arising from the seperation of authority and responsibility.

METHODOLOGY

A cost structure model of a higher education institution's budget was developed using a FORTRAN subroutine to the State Planning System (SPS) modelling framework developed at the National Center for Higher Education Management Systems. (Huckfeldt, 1977)

The model separates expenditures into fixed and variable cost. The model permits analysis of the present budgetary flexibility at the institution and permits examination of institutional sensitivity to policy changes. The model is capable of both inter-institutional and inter-departmental analysis. However, for the purpose of this paper the model was used only to examine the cost structure of the University of Colorado, Boulder campus in the aggregate.

Data for 1974-75, was gathered from budget request documents of 1973-77, Joint Budget Committee Appropriation reports, and Colorado Commission on Higher Education reports. Projections were made for the years 1976-79. A limited set of hypothesis were postulated and tested.

Model Design

The cost structure model is designed as both a deterministic simulation model and a goal programming optimization model. The system uses the NCHEMS State Planning System (SPS) as a general framework which permits both simulation and optimization. The

equations within the model permit both simulation and optimization within an institution. The analyst can test the effects of changes in student enrollment- by program and level within an institution. Inter-institutional analysis could be achieved by placing all variables within a loop for each school, while maintaining a logical loop over all schools.

Other costs that are developed in themodel and used in policy analysis include the traditional fixed cost of facilities, variable costs of supplies, etc., and most importantly the fixed cost of personnel to whom a long term contractual, or at least political-moral committment has been made. This last category includes the classic tenured faculty and the classified civil servant.

Higher education's movement of costs from variable to fixed may have been made to follow private enterprise where growth has seen a shift of cost from variable to fixed. In the pure exchange economy such action is taken to improve the technical coefficient by using fixed capital expenditures for equipment to provide a reduction in the production cost per unit (Stigler, p. 135). The exchange economy model shows an economy of scale operating whereby total average cost declines over the relevant range of production, and marginal cost is less than average cost. Demand constraints, at a fixed price level, provide the incentive to fix the level of production. Higher education however, has shifted its variable cost into categories of fixed staff cost, and combined with the fixed cost facilities cannot demonstrate an economy of scale, beyond a low level critical mass.

Movement of costs from variable to fixed in higher education has not changed the technical coefficient of production in the aggregate as shown by the stableness, and even increase in the average cost over time.

One reason for the lack of improvement is explained by examining the change in programming breadth which characterizes American higher education during its period of rapid growth since 1946.

> ...as institutions grow in size they tend to offer degrees in increasing numbers of fields often adding expensive fields, such as sciences and engineering. Our data suggest that the variable, 'number of fields', tends to exert its influence, at least to some degree, in the direction of increasing costs with rising enrollment, thereby acting as a counterforce to factors tending toward economies of scale. (Carnegie, 1972, p. 164)

This statement based on extensive research among American universities exemplifies the situation at the CU-Boulder campus, even to identifying the academic fields which grew the most at CU-Boulder, science and engineering. This is best explained by remembering that the criteria for resource allocation used by state budgeteers were the student/faculty ratio, and resultant average cost based ratios. Since the institution can experience marginal cost being below average at the micro level of course section size, and can also use the graduate students acquired with the doctoral program as low cost instructors, the marginal cost of additional students at the undergraduate level was well below average institutional cost. (Jedamus, 1970)

During a period of growth institutional policy seems to have been to expand role and mission and spend all resources in order to justify costs. This policy has led to the present breadth of program at its current student enrollment level. In Colorado the lowest cost per student schools are Fort Lewis, and Metro where institutional policy has been explicitly to avoid all graduate programs. Fort Lewis keeps its undergraduate curriculum at 22

academic program majors. Their president, an economist by training, has indicated that such a constraint upon their personal aspirations is necessary in order to contain costs. (Berndt)

Budgetary Disincentives

In state government financial policy there is no incentive to return monies saved to the general fund. Rather the explicit policy is that any money saved one year will be expected as savings in subsequent years. A policy of cutting the base for one time savings will tend to lead government sector managers, including higher education administration, to seek to minimize repo ted savings by spending funds which might be saved as soon as discovered and definitely by the end of the fiscal year.

Higher education institutions made sure that any savings which occurred during the period of student growth were immediately reinvested in a programmatic expansion. State decision makers became concerned with this practice, and it was one of the reasons for establishing the Colorado Commission on Higher Education in 1966 to curtail the expansion of role and mission by the institutions. It cannot be proven here that the state level control over program curtailed the rising average cost shown for the 10 years prior to the commission formation, but the constant dollar average cost shown in figure one did level out at that point.

A further strengthening of state level control over institutional management began during the late 1960's as budget analysts were hired at the state agencies and began to conduct their analysis of budgets in a detailed manner. The appropriations from the legislature began to be at a lower level of control, more line items.

The erosion of confidence in institutional management paralleled the increase in the average cost curves, and were perhaps related. Lump sum appropriations to state agencies, particularly higher education, ended and institutional budgetary autonomy began to decline. This state level change in budgeting style and aggressiveness in review was not unique to Colorado but occurred throughout the United States. (Glenny, 1975)

Only with the recent stability of student enrollment at the major universities have state decision makers begun to reduce the level of appropriation detail, but the new level is meaningless. The analysis still occurs at the detailed level, and any change in expenditure must be justified at the detailed level. The aggregation of appropriation has little real affect upon management flexibility. The distrust of institutional resource allocation policy has led to state control, in Colorado, of the number of employees permitted. The appropriation of FTE (full time equivalent employees) was instituted in 1972 for all state agencies. This policy of controlling FTEs shows the concern which the legislature developed over the hiring practice of state government.

Also in this period of growth the Colorado legislature decided, through its Joint Budget Committee, to control the expenditure of all resources at the colleges and universities. The indirect cost recovery funds from sponsored research became part of the appropriated funds. In addition the cash income of computer centers and like activities became part of the appropriation. In several instances the state budgeteers provided an institution with a requested increase in expenditure, but indicated that this

increase would have to come totally from an increase in cash income, not from the general fund. Often this practice led an institutional manager to promise more income than possible which led to a supplemental appropriation from the legislature to offset the over expectation of cash. The tactics used by the institutional manager to acquire equipment, or even honest mistakes made in estimating outside revenue, increased the level of distrust held by state level decision makers and caused a movement to more tightly control expenditures.

Incentives for institutions to earn other income were diminished. Since the individual faculty member can earn little beyond his own salary, summer employment and a specified level of consulting, and since the institution cannot utilize the indirect cost recovery monies for programmatic expansion, or as seed money for additional research the incentive to seek outside income declines. One area of CU-Boulder where this is apparent is the computer center which has no incentive to seek outside users since the additional income cannot be used to increase the expenditures, even to cover the additional variable cost incurred at the center to serve the additional users. Rather the additional cash will only be used to diminish the portion of support provided by the general fund. Such a reduction will cause the general fund supported user to diminish his use of the equipment since federal contract policy requires equal treatment on a dollar cost basis.

Other examples of the dis-incentives for gathering outside, non-state funds exist and are openly discussed in budget request documents. The institutions general cost picture changes from this lack

of incentive since they seek fewer outside dollars, grow less, and decrease their ability to have budgetary growth from any source other than student increase. The reasons for this tight control are justified in state decision makers minds since the institutions did increase the fixed cost level of operations during their period of student and outside fund growth. State resource allocators are fearful of continued institutional growth which will cause a long term financial commitment by the state. All too often the research projects brought in, the computers purchased, the equipment and buildings acquired became part of the institutions fixed costs while the funding party originally responsible ceases to contribute to the enterprises support.

The fundamental problem is how to provide institutional flexibility and incentives to attract other funding sources without leaving the state with a large fixed cost enterprise. Under present policies of faculty expectation of tenured status, state personnel and purchasing rules which seek to minimize rentals and non-classified staff the problem continues. The state resource managers are not going to provide institutional flexibility to obligate, and the possible benefits of gathering outside activities to help off-set existing fixed costs will not be achieved.

The potential for continued growth which would sustain the current level of fixed versus variable cost is limited by the present policies. A more detailed analysis of the cost structure and a review of potential changes can lend insight into solution sets for stable state.

RESULTS

Given that higher education budgeting is based on average cost, and given a shift in cost structure from variable to fixed costs several hypotheses have emerged. These hypotheses relate to the causal factors of cost movement under conditions of both growth and decline. In order to test the hypotheses the cost structure model was used to examine the costs of the University of Colorado-Boulder. Several computer simulations were made to determine the cost impact of changes in specific policies under varying conditions. All of the tests were run using 1974-75 as the base year and projecting forward to 1978-79. A longer time period could be examined but that would require a change in computer resource capability.

Simulation Runs Discussed in this Chapter

Run 1 - Initial data base after validation.

Run 2 - No change made to the 1974-75 conditions. Projections made based on continuing relationships. (See Appendix D for detailed listing of data elements and initial conditions.)

Run 3 - Students admitted decreased by 30 percent per year. All other values held constant.

Run 4 - Students admitted, including transfer students, increased by thirty percent per year. Other values held constant.

Run 5 - Net tenure attainment rate changed from current 1.09 percent to .99 percent while enrollment is held constant.

Run 6 - Net tenure attainment at .99 percent with students admitted decreased by 10 percent per year.

These computer simulations were utilized to develop an understanding for the sensitivity of the present cost structure to policy changes. The technological problems in developing analytic models of resource allocation strategies are relatively simple and for the most part accomplished. Analytical models have lacked two dimensions, cost structure, and revenue source tracking. This paper presents the need for, and a process by which, cost structure can be utilized for resource allocation analysis. A revenue tracking analytical framework is relatively simple to add to the cost structure model if institutions have the expenditures available by revenue source.

The most critical methodological problem still unresolved in higher education analytical modelling concerns the development of a procedure to determine the performance evaluation criteria. Research into the explicit and implicit criteria of each decision group and the relative weightings among the several conflicting goals and groups is necessary to focus resource allocation analysis.

The cost structure model has been developed in a computer based environment to permit the extension of its operation into analysis using multiple criteria in both a simulation and an optimization model. The basic relationships are simple enough to permit calculator style analysis, but detailed computer analysis provided insight into causal relationships which otherwise might

not have been possible. Simplification seems to come only after understanding has been gained.

A minimum of detailed information has been included in this chapter to simplify the analysis of the hypothesis. A copy of one full simulation run is contained in Appendix D and summary report samples are in Appendix E.

Hypothesis One

Cost is a direct function of the student full time enrollment as the enrollment increases. Figure one in chapter three (p. 40) shows that as the number of students increased the cost per student in both current and constant dollars maintained an upward trend both at the University of Colorado-Boulder and nationally.

Hypothesis Two

Cost is a function of the committed wages and salaries of faculty and staff as the enrollment declines.

Figure two, and table two illustrate present conditions. The breakpoints show the level of students who can be served by present facilities, tenured faculty and sixty percent of the classified staff (representing those who are most likely a fixed obligation of the institutions). Since the legislature has funded institutions on an average cost basis legislators would expect that the cost could decline along line AB under decline. However, costs will decline along line BIC since the fixed cost component of institutional commitments will serve up to 13,631 students before variable cost faculty need be hired. A drop below 13,631 students will not reduce the cost of faculty, nor of staff below 11,866 students

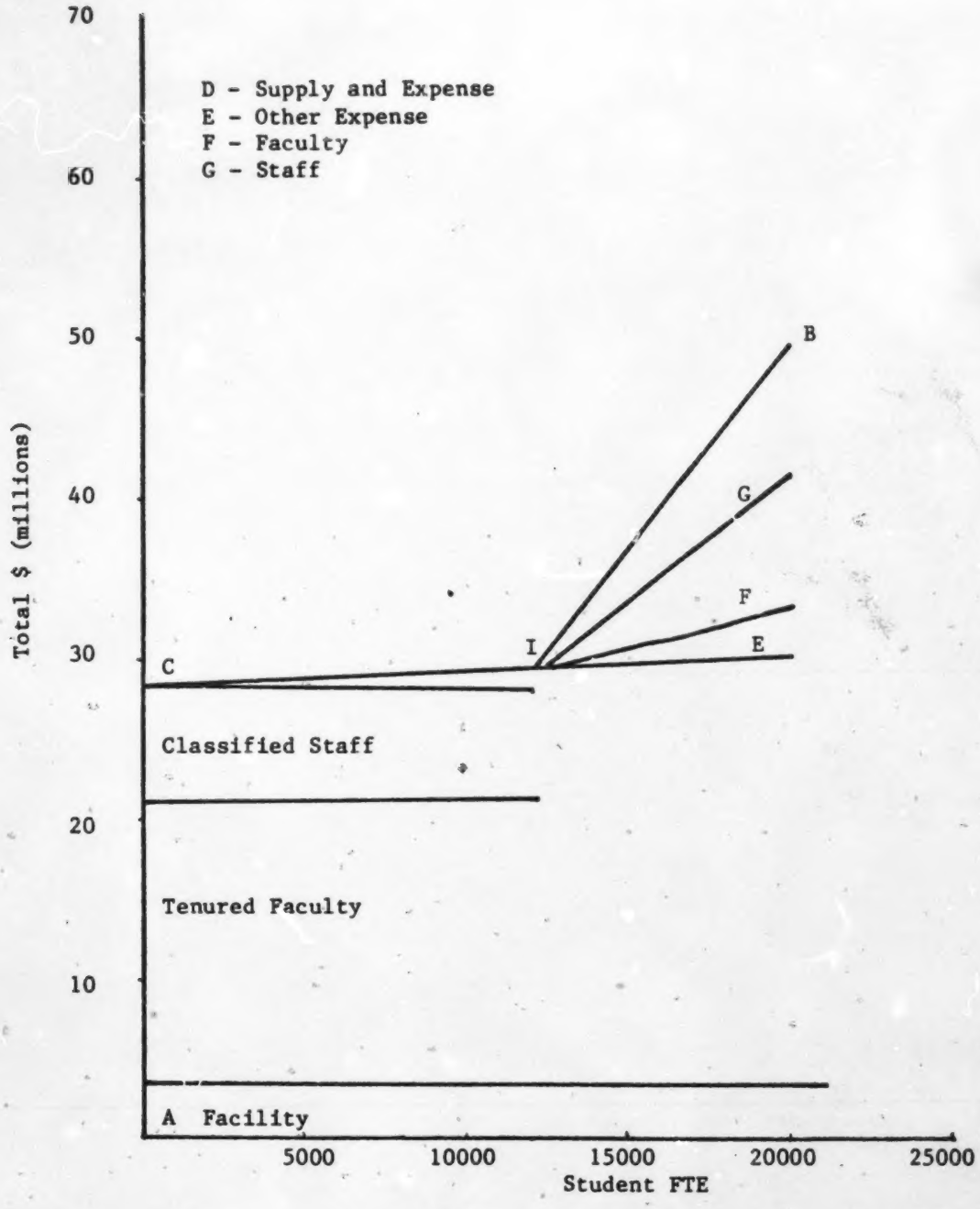

Figure 2. Current Cost Structure - CU-Boulder

unless individuals who are presently under long term commitments are layed off. The actual number of students who can be served by committed personnel actually is more difficult to calculate since individuals are available only for their disciplines or work specialities and an under or over supply will occur at the academic discipline and student course levels.

Figure three shows a second effect of fixed cost personnel and facilities growth. There is an upward movement of fixed cost over time which causes an increase in the level of students needed to equal the supply fo fixed cost resources. The breakpoint of I1 is less than the second breakpoint I2. A higher level of student enrollment, 18,030 students in simulation run four, can be served with committed cost faculty. Present policies will increase the level of students who can be served by fixed cost personnel making the institution more susceptible to high cost in an environment of student enrollment decline.

Hypothesis Three

A static description of the costs in relation to full time equivalent enrollment reveals a discontinuous marginal cost curve.

Figure four, page 75, shows that average fixed cost and average total cost decline as student enrollment increases. What is not shown is that with student decline below five thousand students the average total cost will become equal to average fixed cost plus supply and expense variable cost and average fixed cost will become asymptotic. The marginal cost is a discontinuous curve with breakpoints determined by the level of students served by fixed

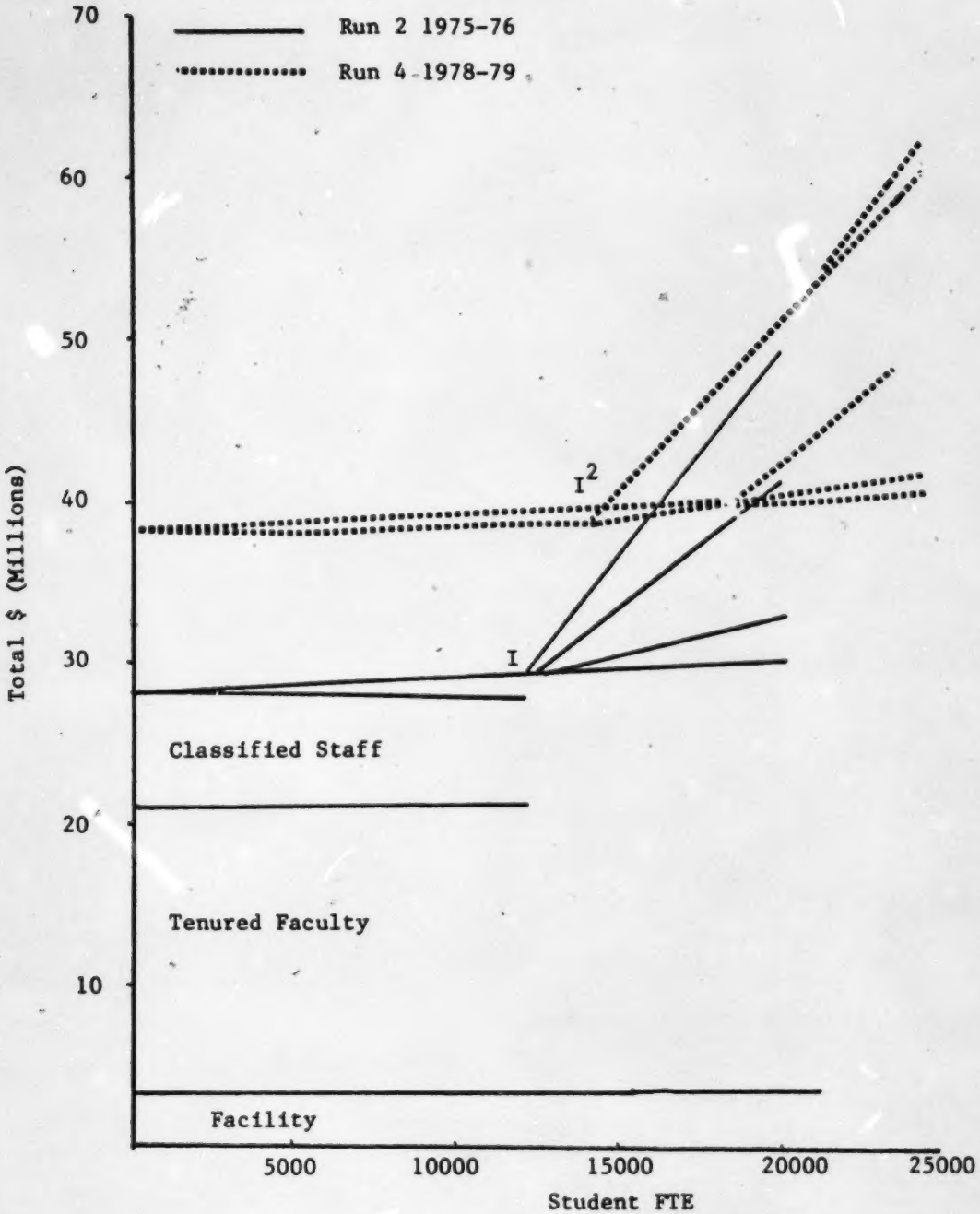

Figure 3. Current and Potential Cost Structure

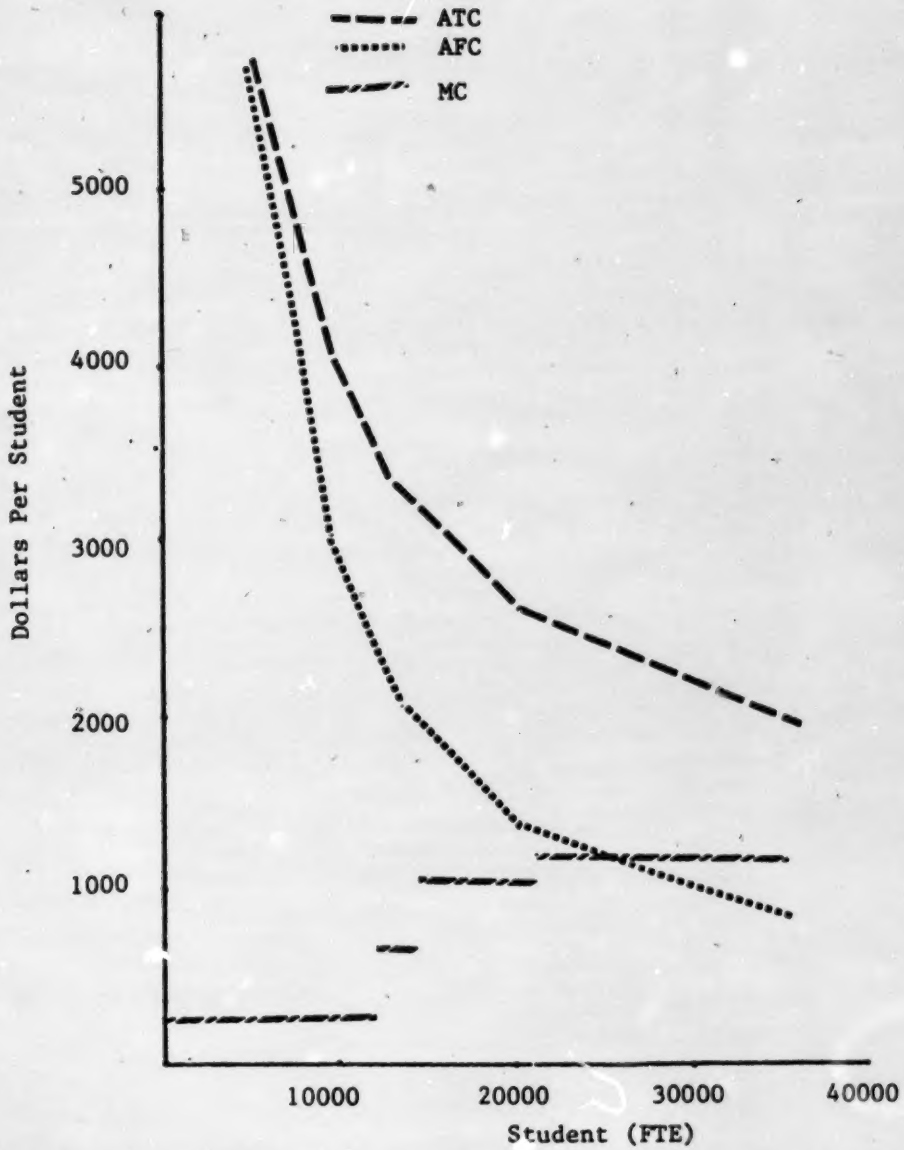

Figure 4. Average and Marginal Cost

TABLE 2

HIGHER EDUCATION COST STRUCTURE

	Run 2 1975-76	Cumulative	Run 4 1978-79	Cumulati
Number of Students	20,000		24,426	
Fixed Cost 1 - Facilities	2,721,296	2,721,296	2,721,296	2,721,29
Fixed Cost 2 - Tenured Faculty	18,782,694	21,503,990	26,937,928	29,659,22
Fixed Cost 3 - Classified Staff	6,874,256	28,378,246	8,635,936	38,295,16
Variable Cost 1 - Supply and Expense	2,057,000	30,435,246	2,442,615	40,737,77
Variable Cost 2 - Other Expenses	3,102,157	33,537,403	1,139,122	41,876,89
Variable Cost 3 - Faculty	7,702,735	41,240,138	7,912,259	49,789,15
Variable Cost 4 - Staff	8,516,152	49,756,290	10,929,544	60,718,70
Variable Cost 5 - Facilities	-		381,969	61,100,66
TOTAL		49,756,290		61,100,66
Break Point 1 - Facility	21,000		21,000	
Break Point 2 - Tenured Faculty	13,631		18,030	
Break Point 3 - Classified Staff	11,866		13,674	

Other expenses represents the difference between supply and expense costs, and the cost of variable cost faculty, staff, and facilities.

TABLE 3

AVERAGE AND MARGINAL COST

Student Number (FTE)	500	1000	5000	10000	12000	13700	20370	35000
AFC 1 - Facility usage	9443	2721	544	272	227	199	132	78
AFC 2 - Tenured Faculty	37565	16782	3756	1878	1565	1371	913	537
AFC 3 - Classified Staff	13749	6874	1375	687	573	502	334	196
Total Average Fixed Cost	56757	28377	5675	2837	2365	2072	1379	811
AVC 1 - Supply and Expense	100	100	100	100	100	100	100	100
AVC 2 - Other Expense	151	151	151	151	151	151	151	151
AVC 3 - Non-Tenured Faculty	374	374	374	374	374	374	374	374
AVC 4 - Staff	414	414	414	414	414	414	414	414
AVC 5 - Facility Rental	132	132	132	132	132	132	132	132
Total Average Variable Cost	1171	1171	1171	1171	1171	1171	1171	1171
Averate Total Cost	57928	29548	6846	4008	3536	3243	2550	1982
Total Marginal Cost	251	251	251	251	665	1039	1039	1171
Marginal Cost 1 (VC1 + VC2)	251							
Marginal Cost 2 (VC4 + MC1)	665							
Marginal Cost 3 (VC3 + MC2)	1039							
Marginal Cost 4 (VC5 + MC3)	1171							

cost facilities, faculty, and staff as shown in table three.

At all times the marginal cost is less than average total cost since the variable cost components being added during immediate growth are always at a lesser average cost than the long term fixed cost component. The temporary and part time faculty are always at a salary below full time, as are other personnel being added. Changing from variable cost to fixed cost faculty and staff has never been justified on the criterion of cost savings. Rather, these shifts have been justified on the need for faculty to perform functions other than teaching and these functions have historically been performed only by full time tenured faculty. The quality of full time tenured faculty has also been assumed to be greater than part time or short term faculty leading to a desire to limit the percentage of non-tenured, short term faculty. In the case of faculty tenure the decision is usually made by a department which does not have responsibility for keeping the cost low, but only for performance against qualitative standards set by university officials and outside accrededation boards.

Additional Results

Perhaps most important for policy consideration is finding that there is a continual growth in the proportion of costs which are fixed. During period of growth the fixed costs increase although not as dramatically as when an enrollment decline is introduced. The results of several simulations indicate that even with changes in policy the fixed cost percentage will not be affected significantly unless the faculty percentage who are tenured is reduced below or just under a present maintenance level. The ability to absorb

a decline in student enrollment lessens each year that total fixed costs are permitted to increase.

The key ratio in understanding budgetary flexibility is the tenure rate. As figure five shows, the percentage of expenditures which are a fixed cost will continue to increase under conditions of stable enrollment and current tenure attainment policy, given the present age of faculty (Run 2). Under conditions of student enrollment growth and decline, but with current policy, the percentage of fixed cost will also increase as shown in runs three and four. Of course, under a condition of student decline the percentage grows faster, and under growth certain changes in policy should make a drastic difference in flexibility for future years. Under conditions of tenure attainment becoming less than attrition, runs five and six, budgetary flexibility begins to improve.

Other policies could be changed to improve flexibility, such as classified staff policy, or facilities flexibility etc., but the primary determinant is the policy regarding tenured faculty. It should be noted that these runs are based on only sixty percent of classified staff being considered a fixed cost. In political terms perhaps all classified staff are a fixed cost. If that assumption is made then budgetary flexibility goes to almost 0 within five years under a condition of student enrollment decline as fixed cost becomes almost 93% of total expenditures, run 7.

The stabilizing effect shown particularly in run 7 results from some expenditures, such as supply and expense being considered in the simulation as necessary, although variable, throughout the range of operation.

TABLE 4

FLEXIBILITY INDEX

Fixed Cost as a Percent of Expenditure

	74-5	75-6	76-7	77-8	78-9
Run 2 no changes	.60	.60	.64	.71	.71
Run 3 Admitees down 30%	.60	.62	.68	.73	.73
Run 4 Admitees up 30%	.60	.59	.60	.66	.66
Run 5 Tenure rate to .99% enrollment constant	.60	.60	.62	.66	.64
Run 6 Tenure rate to .99% Admitees down 10%	.60	.62	.66	.72	.71
Run 7 Admitees down 30% classified staff all	.82	.87	.93	.93	.93

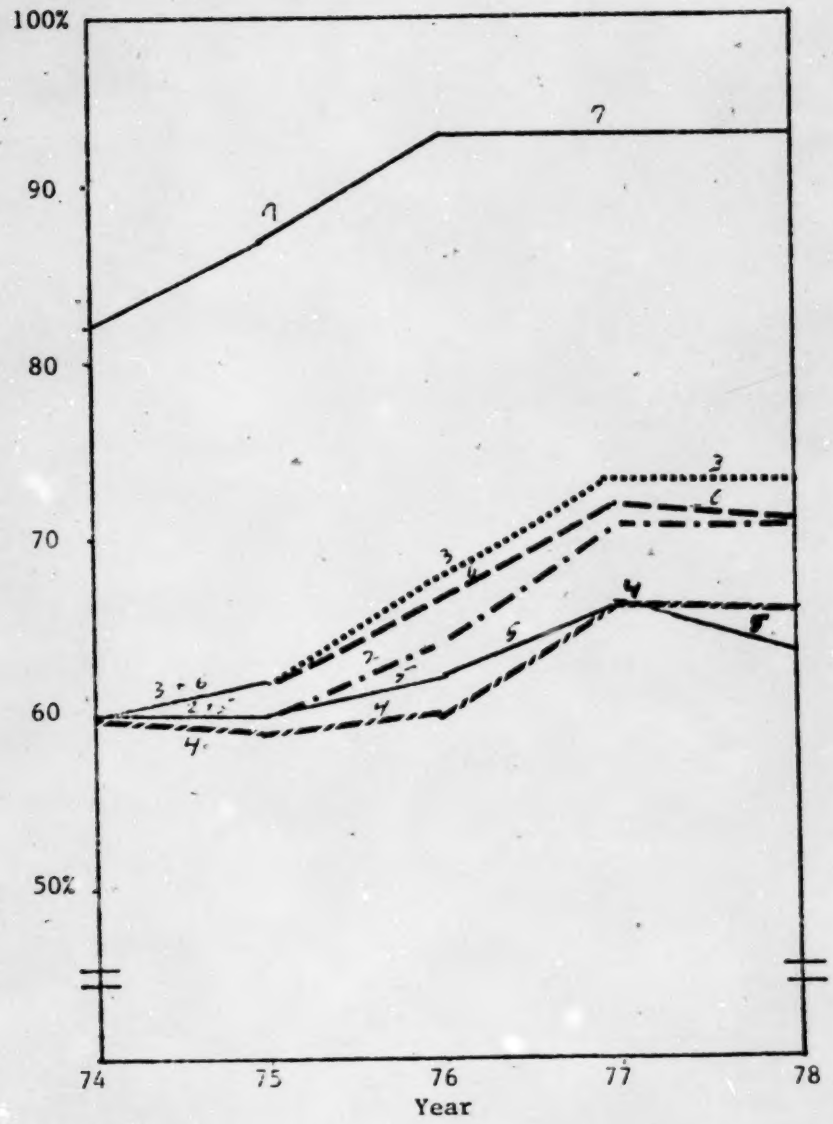

Figure 5. Flexibility Index - Fixed Cost as a Percent of Expenditures

Analysis Summary

Although student enrollment decline causes the institution to encounter budgetary problems sooner, even with constant student enrollment the present policies of tenure attainment, staff employment policy, and the cost of existing facilities will lead to a reduction in budgetary flexibility for future years.

The combined effect of these movements in cost structure is to increase the level of students needed to cover a break-even point. Long term conversion from variable to fixed will make the predicted student enrollment decline quite costly.

IMPLICATIONS FOR HIGHER EDUCATION POLICY

Decisions regarding public higher education are made within an environment of demand factors, and of basic societal conditions. Policies are made to maximize performance toward a set of prescribed goals. The degree to which goals are met is determined by a set of evaluators who primarily represent groups which provide the revenue to operate. Each of these evaluation groups has a set of criteria, but the criteria are not always shared, nor even complimentary. The conclusion from studying and developing an understanding for higher education cost structure is that several policies need to be changed in order to better operate the system given the current and projected environment.

Environment

A change in student enrollment growth patterns to steady state or decline alters the basic nature of the industry. Policies which may have produced excellent goal satisfying behavior may have the opposite effect when the system experiences student enrollment decline. Higher education policy is also made in an environment where the general price structure of the factor inputs, personnel, supplies, utilities, facility cost, etc., may have large scale structural changes. Recent inflation has affected higher education as an industrial sector more greatly than the general economy due to the mix of factor inputs peculiar to the higher education

industry. (Halstead) Higher education policies may have to change if the societal price structure was to change.

American higher education is also in a particular cultural environment, where education has been utilized at the onset of a career, and used very little for life-long learning or career change. A culture such as modern day China might necessitate radical policy change since the provision of continuous changes in roles, between teacher, student, factory worker, farm worker would necessitate a radical change in the higher education policy set.

Public higher education policy primarily reflects these broader societal conditions, and does not have a great deal of influence upon overall inflation, or work conditions, or even student enrollment. Rather these are exogeneous or given factors for higher education to work within, and to which it responds.

Policy Alternatives

Public higher education has such a large percentage of its costs committed primarily due to personnel policy. As table four shows the University of Colorado-Boulder currently has 64 percent of all expenditures committed to fixed costs. An enrollment decrease of 30 percent of admittees per year (run 3) will cause 73 percent of expenditures to be fixed leaving only 27 percent of cost as controllable. Under policies and conditions of 1974-75 this move would occur by 1978-79.

If departmental faculty tenure policy was to continue as in 1974-75, and other conditions, such as the retirement rate were to hold steady, almost the total faculty would be tenured by 1980. Since some departments already have 100 percent tenured faculty

some shift in this indicator is already occurring.

Throughout the country a group of younger faculty are adjusting to the possibility that tenure will not exist for them at any institution. They are becoming a group of academic nomads. They are denied tenure when individuals of lesser quality were granted such tenure only five years ago. This nomadic group continues to suffer from other conflicting policies, such as rules which permit no one to stay at an institution without tenure for more than three years. Of course, the academic administrator who is reviewing applicants for positions can also no longer use the number of jobs within the last 10 years as an indicator of probable applicant quality. But, many administrators still think in the old manner and will begin to pass up the earlier nomadic entrants, for more recent graduates who do not have the stigma of many jobs on their record.

The movement of staff from yearly contracts to long term civil servant status also inhibits management flexibility. Long term commitments should be made in the context of employment for the State, or for the total higher education system, not promises of long term employment at any one specific institution, location or department.

Other feasible policies could be developed regarding non-teaching staff to provide less of a need for and expectation of longevity. Perhaps a greater acceptance of student labor, coupled with internships in their academic program will provide staff support and academic meaning.

Personnel policy regarding retirement plans, and reward structures should also be examined. Early retirement plans have proven financially beneficial to several institutions and CU-Boulder might also be able to improve flexibility and perhaps even save money by encouraging early retirement. Specific studies are necessary to cost the alternative retirement plans. Extensions of work conducted by Toole and by Hopkins would be necessary for detailed evaluation. (Hopkins, Toole, 1972) An examination into increasing work loads while increasing salary, or year round work for faculty might prove cost effective in the long run if coupled with a reduction in tenure expectations.

A reduction in an employee's contractual expectation of long term employment will lead to higher present salary demands since long term employment reduces risk, and the increase in perceived risk will create a demand for higher pay now.

Since facilities represent the other component of fixed cost any improvement in utilization rate will reduce the demand for replacement or enhancement. The present policies have led to very low utilization rates when considering a 24 hour day, 7 days a week. The policy of building facilities to accommodate a peak load of approximately fifteen hours a week, from 9:00 am to noon seems a costly policy and may reflect the lack of personnel control through an incentive or positive reward system. The construction of facilities to meet evening student demand in urban areas needs even greater study since it would seem reasonable to expect that evening utilization of other faciliites, such as the public schools, government conference rooms, private business facilities, etc.

would prove less costly, in both the short and long term. The ability of continuing education programs to make such use, and realize the cost savings, should illustrate the need for consideration of this policy for state supported programs. Both changes in staff long term employment expectations and the reduction in facility demand provide greater flexibility to management by offering a larger percentage of expenditures as controllable resources.

Perceived fiscal crises seems to cause employees to become insecure about job status and reject technological improvements. During the period of enrollment growth several technological improvements were offered as resources to aid instruction at a lower cost than increasing the faculty. Computer Assisted Instruction (CAI), and Education Television (ETV) were both promoted as technological means to improve instruction at a lower cost than providing additional personnel. However, the experience has been that CAI and ETV have been purchased along with additional staff leaving funding agents disenchanted with the prospect that either innovation would provide a cost savings. CAI and ETV have only been qualitative improvements. An increase in the use of Computer Assisted Instruction and Educational Television may provide a means of reducing long term cost, but such an argument will be difficult to test and prove if discretionary resources continue to diminish. Perhaps an environment of competition for student consumers will provide the necessary incentive to lead to technological changes.

Higher education has primarily been a supply dominated industry where access was controlled and demand very high. With a reduction in demand the urge to attract consumers might encourage innovation, and in particular the use of Computer Assisted Instruction. It is still not proven, however, that Computer Assisted Instruction and other improvements are any less expensive than faculty cost, nor any less a fixed cost investment.

Other policy changes to improve the productivity of higher education might focus on the use of existing faculty and staff. The present, and long standing, policy of providing undergraduate instruction with about a twenty to one student to faculty ratio, while doctoral level education operates at about four to one can be challenged. The simulation model illustrated the high cost of graduate instruction. The relationship with student faculty ratio is very direct. It has already been suggested by a former chairman of the Colorado Legislative Joint Budget Committee that the need for direct faculty involvement with students is probably greater at the elementary-secondary school level, or the remedial and undergraduate level in college, than at the doctoral or masters degree level. The historic reasons for developing such a low graduate level student faculty ratio were primarily due to the small numbers in the program, as well as a means to protect senior faculty members from a heavy teaching obligation thus permitting them greater opportunity for unsponsored research and public service activities. CU-Boulder could reassign over 250 faculty members by making their graduate level student faculty ratio the same as undergraduate. (1976 CU-budget book, format 50m)

The quality of graduate education might be reduced, but since this idea has not been studied it may be worthwhile to examine. The two most likely prospects are, one, that the faculty member is wasting that much time per week, or two, that the faculty member is indeed working hard, but perhaps on unsponsored research, committees, and other non-instructional duties. A review of faculty time commitments could lead to a re-structuring of the reward system to encourage heavier teaching loads. Presently, research produced is the primary criterion to measure individual achievement, reducing the incentive for quality instruction. Making the research commitment more explicit and seeking direct funding for it a faculty member's contribution would be a reasonable effort and provide for greater institutional credibility. Of course, it could merely separate research activity out and cause it to be eliminated from the budget. However, if the decision process is explicit then a decision maker must operate in the open and be accountable.

Perhaps the total role and mission of the institution relative to research needs to be examined. Research is a secondary goal of the University of Colorado-Boulder according to the resource allocators in Denver. However, it is the most important of missions if one asks the departmental hiring, promotion, and tenure committee. Several alternatives for correcting the goal conflict are possible. Research could be identified as a consumer of faculty time more explicitly and legislators could be educated about the need for such research. Such a separation from instruction would be beneficial in a time of student decline, and research continuity.

A shift in staff assignments to permit aggressive research support seeking faculty members to spend more time in proposal writing, while using less research-oriented faculty for teaching should increase outside support for research. A switch to aggressive searching for outside research support would need to include an expansion of support staff available to help generate resources. Such a move would also need a change in state budgeters' attitudes to permit the use of outside income in a more positive manner thus providing the individual and the institution an incentive for seeking external funds. This response set is very appropriate to a period where excess staff, fixed or sunk cost individuals might exist. Many academic departments have already decreased in enrollment and excess faculty time may exist, but not the incentive and support for seeking funds. More fundamentally the department which first has excess staff might also be the academic area least likely to be able to get outside funding. A minor retraining of the excess faculty to help the more 'in style' departments with both their teaching and research loads could be developed.

Proposals have already been made to use faculty as a pool of research talent to be applied to state needs. Such proposals might be better understood as a package of fundamental changes to help cover a sunk cost. If buying out a 50 year old faculty member's contract for a cost savings of perhaps only 20 percent seems feasible, then one should consider what other products are possible from that individual which will return at least 20 percent of each dollar. It is not necessarily a credit to our universities to become

the leaders in early retirement when society is just becoming aware of the negative effects of early retirement to many individuals.

There is an even more comprehensive set of responses which are possible. China has shown that a total shift in lifelong employment patterns can have some positive benefits. Perhaps an extension in exchange programs between professors and executives makes the teacher role temporary in nature. Each professional should plan to spend part of their time teaching, and each teacher should become identified with the larger work force of his profession, and not as a full time tenured for life professor. Such fundamental change is not as likely as other alternatives, but movement in this direction would have a powerful effect on the rigidity of faculty employment expectations, and should reduce the fixed cost component of faculty salary.

A review of academic program offerings to determine the specific ones which are of high quality and high demand relative to other programs is often discussed but seldom conducted. The rapid expansion of programs, both of type and level, which occurred during the growth period of the sixties has led to a wide range of offerings within each institution, and each state. The control of program offerings is deemed to be most effective means to control costs. (Carnegie, 1972)

Determining the criteria for program review has been the major difficulty in undertaking, and completing such program evaluation efforts. Criteria for review appears the fundamental difficulty in any policy study of the higher education industry.

This study has focused primarily on the criteria of a balanced budget, or cost containment. The study of higher education cost structure has been undertaken to produce an understanding for the lack of current budgetary flexibility and the potential of fiscal crises if current policy is maintained during a period of static enrollment, or enrollment decline. However, higher education has many goals to serve, many of which are contradictory.

Beside the goal of cost effectiveness the institution is attempting to educate, or train students; provide access to education according to principles of equality; provide an economic stimulus to local communities; and to operate in a process of employee equity by providing equal opportunity employment, and promotion rights.

Another important goal is to use higher education as an economic stimulus to a local community. Cutbacks at the University of Colorado-Boulder and at other institutions would have a dramatic effect on local economies, and in the aggregate state economy. The movement to Boulder and growth of research and development enterprises such as the National Center for Atmospheric Research (NCAR), the National Oceanic and Atmospheric Administration (NOAA), the Bureau of Standards (NBS), International Business Machines (IBM), etc. have occurred simultaneously with the growth of the University and its emphasis on the physical sciences. A reduction in the quality or quantity of the University's effort could stop growth and perhaps erode these organizations. Any downward change in these groups would only contribute to a negative cycle of economic loss for the local community and the state. (Cross)

Any review of higher education productivity needs to address these multiple goals and the numerous quantitative objectives upon which performance toward these goals is evaluated. Simple arithmetic might be sufficient sophistication to examine policy alternatives directed toward the single objective of a balanced budget, but a thorough performance review should permit the evaluation of multiple policies against multiple performance criteria, some of which have non-linear and indirect interdependencies.

Performance Criteria

Acknowledging that public higher education ha.. many goals still does not provide an understanding for the evaluation process. Higher education provides services to many funders each of which has performance review criteria. The legislature seeks to represent all state residents in evaluating an institution's progress toward the goals which the legislature has set. Legislative goals tend to focus on student credit hours produced, working conditions, and student access. Legislators also seek to help the institution satisfy the numerous accreditation boards, another set of evaluators with perhaps different criteria than the legislature.

The legislators seek to represent the general public's demands and criteria but frequently the public will develop its own set of criteria, particularly the citizens located within a university town. The local population may force the institutior to provide amenities, or services that the legislature will not explicitly fund, such as a symphony performance although such an action affects institutional cost.

Conflict over performance criteria frequently occurs between the legislative funders and research sponsors. Federal government agencies and private foundations which support research are primarily concerned with the institutions research performance even if research activity may have to be at the expense of student instruction. Students are in competition with the research sponsors for institutional resources. The battle ground is explicit when the federal government audits the overhead reimbursement rate for the institution. The institution tries to provide justification for a very high rate, while at the same time telling the legislature that research overhead represents a small portion of its resources and is solely an adjoint activity to instruction. The research sponsor is told that research is their primary mission and that the institution can provide research more inexpensively than outside research companies because it has lesser paid faculty and the availability of low cost, high quality student research assistants.

An additional problem also exists since the stated criteria are not always the criteria upon which a judgement is made. The institution must develop an understanding for the implicit criteria being utilized in their review. Students may have explicit criteria of instructional quality standards while deciding to attend primarily on the basis of dormitory quality, or college location, or auxiliary enterprises. Legislators may be more concerned with the football team's performance than academic awards. Research sponsors may be seeking to spread funds geographically, not solely on quality. Some decision makers may even be using less socially acceptable criteria, such as racial or personal bias for their own

family, or ego's.

Public higher education policy analysis can be summarized as study and analysis of the goals and review criteria, explicit and implicit, of each funding and servicing group, and the priority ranking within and between these groups.

The present lack of budgetary flexibility and potential for worsening should provide stimulus for quick response by administrators. Past flexibility has been obtained by the extra revenue available when student enrollment growth is funded on an average cost basis, while incremental expenditures occur at less than the average cost. A stable enrollment, and even more so a decline in enrollment, illustrate that future budgetary flexibility will only occur through careful management. An institution's response set can be categorized according to the present level of budgetary flexibility. If there is little budgetary flexibility then the response set is truly draconian. People may be layed off, buildings closed, programs eliminated without careful review. Given some budgetary flexibility and time for review the response pattern can be graceful. An orderly set of policies to cope with an impending problem would lead to changes in tenure rates, shifts to non-long term contracting, the elimination of new building plans, the rental of short term facilities for short term needs, the orderly review of programs, a shift in role and mission, etc.

Of course, the most far sighted manager will have already begun to make policy changes in anticipation of a student decline, or stable state. Such a response pattern could be creative as suggested by Kenneth Boulding. (Boulding, 1974)

Managers who heeded the early warning signs and began program review, and personnel policy changes should have greater budgetary flexibility now, and to have created a positive attitude within which creative ideas flourish. Technological innovation is more likely among a group of faculty who are looking to future conditions with their own security established. A positive attitude would use the enrollment change as a catalyst to new policies which may be difficult unless an outside threat is perceived, but not yet felt.

Summary

It has been the basic intent of this paper to provide insight into the cost structure of higher education. This paper is prepared on the premise that a mode of inquiry which is based on analytical thought will provide information for decisions which are conflict reducing and knowledge enhancing. Kenneth Hammond has developed a paradigm of inquiry modes which gives a framework for analytical efforts such as this thesis. (Hammond, 1977)

Figure 6 shows that efforts to deal with the experimental method, including data analysis, will provide more conflict reducing, analytical, decision processes. In that sense I have tried to provide an insight into the cost structure of higher education and the resultant flexibility problem which might lead us from level six toward level five.

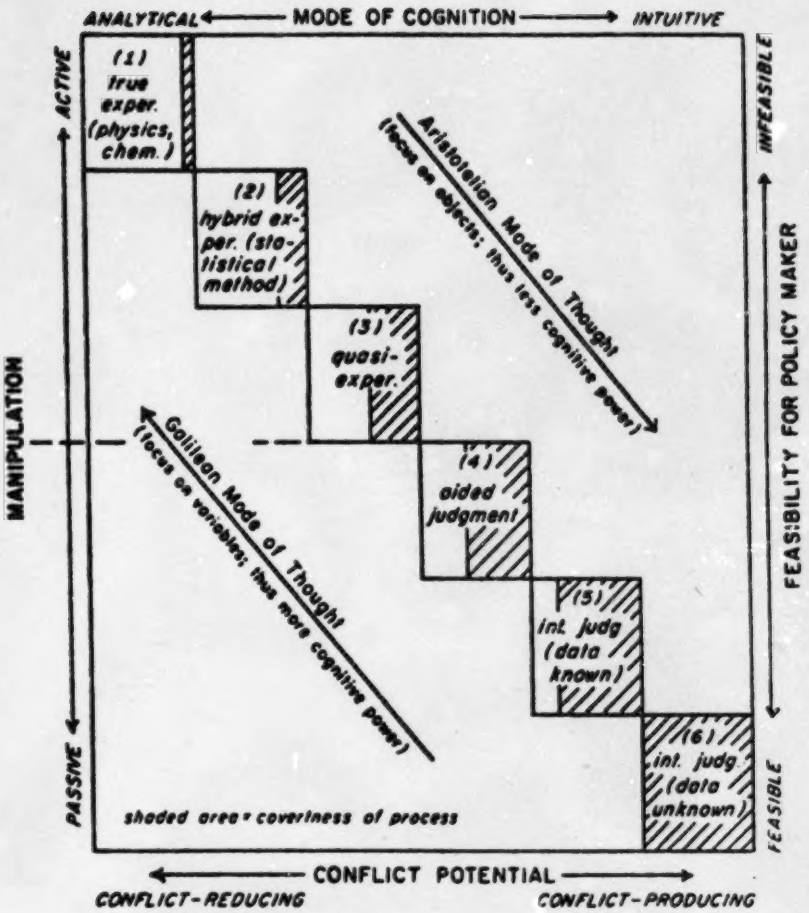

Figure 6. Modes of Inquiry

POTENTIAL EXTENSIONS OF THIS STUDY

This thesis is a policy thesis and as such utilized the structural cost model only on aggregate data and relationships with the information necessary to raise the policy issue of resource allocation inflexibility caused from a change in the cost structure of a higher education institution. The implications for additional research are numerous. The need for utilizing a computer based model increases when one extends the present study to include a number of explicit and implicit evaluation criteria in a framework of maximizing performance against an objective function containing multiple objectives which have various weightings and inter-dependencies.

Intra-Institutional Analysis

In making resource allocation decisions within an institution it would be important to understand the cost structure of each production unit, department. Some academic departments may already have reached the point of maximum inflexibility, and resultant high cost. Other departments may be on the verge of losing the flexibility which they may need in the near future. An analysis of intra-departmental cost structure would be beneficial, and can be accomplished using the structural cost model, but with a disaggregation of data elements.

Inter-Institutional Analysis

The state needs to consider its higher education institutions as a multi-plant facility which provides a differentiated product for a set of market segments. This would lead the management structure, state (corporate) and institutional (plant) to seek a greater understanding for the cost structure of each plant, and of departments within the plant, where comparable programs are offered, in a shared geographic market place.

The structural cost model provides the capability to evaluate policies which have interdependent effects upon multiple institutions. The optimization feature which the goal programming capability of SPS provides could examine cost minimization production levels for various student populations and mixes. The optimality of supply among multiple institutions, can be discovered using the goal programming feature.

Detailed Staff Flow Modelling

The structural cost model makes very simple assumptions about the more crucial policy elements of faculty and staff flow. A more detailed module to track individuals through their potential employment patterns would provide greater accuracy in the prediction of future cost functions. Such flow modelling could be an adaptation of work already developed by Bloomfield, Toole and others. (Bloomfield, 1977; Toole, 1976)

Revenue Modelling

The structural cost model has the logic established to examine alternative tuition policies. The effect upon revenue of changes in percentage or type of cost charged for tuition; the breakout of tuition cost base for graduate, undergraduate, or even for students by program and level is possible, and should be examined. It would be possible to simulate the point of marginal cost = marginal revenue to help guide resource allocation in a framework similar to an enterprise in the pure exchange economy.

Decision Analysis

A very interesting extension of the cost structure model would be its use in developing interactive dialogue coupled with policy capture techniques. The model could easily be adapted to real time simulation. The extension of its logic to include the policy weight capturing and analysis techniques developed by Hammond and Stewart would provide an excellent analytical extension, and attitude change tool. (Hammond, 1975)

The differing perceptions of institutional administrators, department versus university; budgeting staffs of state agencies, and of board and legislative members would be valuable to understand. The differing perceptions of the existing level of flexibility and potential policies could expand the work of Balke and others in terms of labor-management negotiations. (Stewart, 1974)

Graphics Extensions

The model does have a plotting capability available within the SPS framework for developing initial pictures of policy changes. An extension to incorporate interactive plotting would provide greater initial understanding of complex policies.

Theoretical Extensions

An important additional analysis would be an exploitation of the application of this structural cost analysis to other enterprises within the governmental (grants) economy. It may be that all governmental activities are exhibiting this movement to an increasing level of fixed costs. If so, then the implications identified for higher education become even more significant when applied to all governmental operations. The closer examination of the private sector might also lead to a change in our theoretical expectations of industrial cost behavior, due to the structural changes caused with increasing unionization, white collar contracting, etc. Under conditions of decline or steady state the same forces acting on higher education might operate on private enterprises.

Another interesting comparison could be made with other economies. A study which included Britain, and Japan might provide insight into the effects of long term employee commitments. Examination of lesser developed countries might provide a totally different set of policy implications. Inter-economy analysis should be beneficial.

Summary

The last, and only thesis found, which examined cost structure was conducted by Joel Dean in 1937. (Dean, 1937) His work on marginal costing was conducted at the upward end of a long decline and he felt that in decline the value of understanding marginal cost, and other structural cost characteristics was very important. Perhaps the apparent paucity of further work emphasizes our lack of need for such analysis during periods of growth. This could become a fruitful area of research again, if societal growth patterns are really changing.

Bibliography

Ackoff, R. L., "Toward Strategic Planning of Education," Efficiency in Resource Utilization in Education, Paris: OECD, 1969.

Adrian, William B. (contributor), Planning and Management in Higher Education: Promise or Dilemma?, Report No. 26, Education Commission of the States, Denver, 1972.

Adrian, William B., "Planning and Management Systems at CCHE," in Computing and the Decision-Makers, Interuniversity Communications Council, Inc., Princeton, N.J., 1974.

Adrian, William B., "Postsecondary Education Planning in Colorado." Colorado Commission on Higher Education, 1976, 26 pp.

Aigner, Dennis J., "A Note on Verification of Computer Simulation Models," Management Science, Vol. 18, No. 11, July, 1972.

_____, and Armacost, Robert, "An Academic Productivity and Planning Model," Report No. 3, Ford Research Program in University Administration, University of California, Berkeley, February, 1970.

Armitage, P., Smith, C., and Alper, P., Decision Models for Educational Planning, London: The Penguin Press, 1969.

Balanchandran, K. R. and Gerwin, Donald, "Variable Work Models for Predicting Course Enrollments," School of Business Administration, University of Wisconsin, Milwaukee, March, 1972.

Balderston, F. E., "PPBS in Higher Educational Planning and Management: Part I, An Overview," Ford Research Program in University Administration, University of California, Berkeley, December, 1971.

Balderson, F. E., "Varieties of Fiscal Crisis," Universal Higher Education Costs and Benefits, Washington: American Council on Education, 1971.

Bartram, Jack, Interview on May 16, 1977, University of Colorado, Boulder.

Bernstein, Allison R., "Is Giantism the Price of Mass Education?" Chronicle of Higher Education, May 17, 1976, p. 32.

Berndt, Rexer, Testimony to Colorado Legislative Joint Budget Committee, November 15, 1975.

Blaug, Mark, "The Empirical Status of Human Capital Theory: A Slightly Jaundiced Survey," Journal of Economic Literature, Vol. XIV, no. 3, September, 1976, pp. 827-856.

Bloomfield, Stefan D., "A Committed Resources Approach to Faculty Staffing Policies," in Information for Decisions in Post-secondary Education, ed. Robert G. Cope, Association for Institutional Research, 1975.

Bloomfield, Stefan D., "Comprehensive Faculty Flow Analysis," in Applying Analytic Methods to Planning and Management, Jossey-Bass, 1977.

Bottomley, J. A., Cost and Potential Economies, Organization for Economic Cooperation and Development, 1972.

Boulding, Kenneth E., The Economy of Love and Fear, 1973, Wadsworth Publishing Co., Belmont, California.

Boulding, Kenneth E., "Knowledge as an Economic Variable," The Economic Studies Quarterly, Vol. XIV, No. 3, June, 1964.

_____, "The Management of Decline," Address at Regents Convocation, University of the State of New York, Albany, September 20, 1974.

_____, Output, Input, and Productivity Measurement, a Report of the National Bureau of Economic Research, Princeton University Press, Princeton, 1961.

_____, "The Place of the 'Displacement Cost' Concept in Economic Theory," Economic Journal, 42, 165, March, 1932, pp. 137-141.

_____, "The University as an Economic and Social Unit," Colleges and the University as Agents of Social Change (Ed. W. John Minter & Ian M. Thompson, Boulder, Colorado, WICHE, 1968, pp. 75-87.

Bowen, Frank, "State Fiscal Stringency and Public Higher Education," The Research Reporter, vol. X, no. 1, 1976, The Center for Research and Development in Higher Education, Berkeley, California.

Bowen, Frank M., and Glenny, Lyman, A., "State Budgeting for Higher Education: Response of Public Higher Education to Fiscal Stringency." The Center for Research and Development in Higher Education, 1977.

Carlson, D., "The Production and Cost Behavior of Higher Education Institutions," Paper P-36, Ford Foundation Program for Research in University Administration, University of California, Berkeley, December, 1972.

Carnegie Commission on Higher Education, More Effective Use of Resources, McGraw-Hill, New York, 1972.

Cherin, E., Chisholm, M., Huckfeldt, V., and Smith, M., State Post-Secondary Education Planning Model Software System, Boulder: Western Interstate Commission for Higher Education, 1975.

Chickering, Arthur W., "How Big Should a College Be?" Liberal Education, 52, October, 1966, pp. 281-92.

_____, Chronicle of Higher Education, April 26, 1976, p. 2.

_____, Chronicle of Higher Education, May 31, 1976, p. 8.

_____, Chronicle of Higher Education, October 25, 1976, p. 1.

Cohen, K. J., and Cyert, Richard M., "Computer Models in Dynamic Economics," The Quarterly Journal of Economics, Vol. 75, February, 1961, pp. 112-127.

Cohn, Elchanan, The Economics of Education, Toronto, London, and Lexinbton, Mass.: D. C. Heath, 1972, pp. xxi, 392.

Collard, William, and Huff, Robert, "Exploring Cost Exchange at Colleges and Universities," NCHEMS, February, 1974.

Collier, Douglas, "Indicators of Institutional Financial Health," National Center for Higher Education Management Systems, unpublished working paper, January, 1976.

Colorado Commission on Higher Education, Discussion with staff of CCHE, Education Commission of the States, and National Center for Higher Education Management Systems in February 1977.

Correa, H., "Models and Mathematics in Educational Planning," in G. Z. F. Bereday, J. A. Lauwerys, & M. Blaug (Eds.) The World Yearbook of Education, 1967: Educational Planning, London: Evans Bros., 1967, 398-422.

_____, "A Survey of Mathematical Models in Educational Planning," Mathematical Models in Educational Planning, Paris: O.E.C.D., 1967, pp. 21-93.

_____, "Cost Reduction and Input Proportions," Discussion paper, Institute of Public Policy Studies, University of Michigan, August, 1974.

Cross, Marilyn, Better University-Community Relations, University of Colorado, Boulder, 1974.

Curry, Denis J., and Powel, John H., Cost Data Reporting Manual for the 1972-73 Higher Education Cost Study, Olympia, Washington: The Washington State Council on Higher Education, November, 1973.

Cyert, Richard M., "The Management of a Contracting Organization," University Administration, Reprint number 9, Carnegie-Mellon University, Pittsburgh, Pa., 1976.

Danish, Paul, Discussion on March 15, 1977 citing work by the National Tax Foundation.

Dean, Joel P., "A Statistical Examination of the Behavior of Average and Marginal Cost," Dissertation, University of Chicago, 1937.

Denver Post, November 14, 1976, p. 29.

Dodge, Norm, "Opening Fall Enrollment, Colorado Colleges and Universities," Colorado Commission on Higher Education, October, 1976.

Dresch, Stephen P., "A Critique of Planning Models for Post-secondary Education," Journal of Higher Education, Vol. XLVI, No. 1, May/June, 1975, pp. 245.

Dressel, Paul, and Simon, Lou, Allocating Resources Among Departments, Jossey-Bass, August, 1976, San Francisco, California.

Ewald, A. A., and Kiker, B. F., "A Model for Determining the Input Cost of University Degrees," Socio.-Econ. Plan. Science, 4, 1970, pp. 331-340.

_____, "Faculty Development in a Time of Retrenchment," Change, 1974, New Rochelle, New York.

Farrell, M. J., and Fieldhouse, M., "Estimating Efficient Production Function under Increasing Returns to Scale," Journal of the Royal Statistical Society, Series A, Part II, 1962, pp. 252-267.

Firmin, Peter A., Goodman, S. S., Hendricks, T. G., and Linn, J. J., "University Cost Structure and Behavior," Tulane University, 1967.

Fisher, Sam, "CAMPUS/COLORADO Program Costing," Unpublished document, University of Colorado, Boulder, January, 1974.

Fogler, H. Russell, "A Pattern Recognition Model for Forecasting," Management Science, Vol. 20, No. 81, April, 1974.

Fox, K. A., et al., "Formulation of Management Science Models for Selected Problems of College Administration," U. S. Department of Health, Education, and Welfare, Office of Education, Final Report Contract No. OEC-3-068058, Iowa State University, 1967.

Glenny, Lyman A., "Financing Postsecondary Education in the U.S.A.," Higher Education, 1976, pp. 103-107.

Glenny, Lyman, et al., Presidents Confront Reality: From Edifice Complex to University Without Walls, Carnegie Council on Policy Studies in Higher Education, Jossey-Bass, San Francisco, 1976.

Gulko, Warren W., Program Classification Structure, NCHEMS, January, 1972.

Gulko, Warren W., "The Resource Requirements Prediction Model 1 (RRPM.1): An Overview," TR 16, NCHEMS, January, 1971.

Gulko, Warren W., "Unit Costs of Instruction, A Methodological Approach," WICHE, January, 1971.

Haggstrom, G. W., "On Analyzing and Predicting Enrollments and Costs in Higher Education," Paper presented at the meeting of the American Statistical Association, New York, August, 1969.

Halstead, D. Kent, Higher Education Prices and Price Indexes, U.S. Department of Health, Education and Welfare, 1975.

Hammond, Kenneth R., "Toward Increasing Competence of Thought in Public Policy Formation," report no. 203, Center for the Study of Judgment and Decision in Policy Formation, Institute of Behavioral Science, University of Colorado, Boulder, June, 1977.

Harcleroad, Fred F., "Institutional Efficiency in State Systems of Higher Education," American Association of State Colleges and Universities, Washington, D.C., November, 1975.

Hayes, Larry K., "Preliminary State Level Planning for Higher Education Retrenchment," in Cope, ed. Information for Decisions in Postsecondary Education, Association for Institutional Research, 1975.

Hilles, William C., "Program Cost Allocation and the Validation of Faculty Activity Involvement," Journal of Medical Education, Vol. 48, no. 9, September, 1973, pp. 805-813.

Hodgkinson, Harold L., "Planning and Management in the Face of the Changing Demographic Picture," in Information and Analysis in the Context of Institutional-State Relationships: The Tie that Divides Us, William Johnson, ed., National Center for Higher Education Management Systems, Boulder, Colorado, 1976.

Hopkins, David, S. P., "Analysis of Faculty Appointment Promotion and Retirement Policies on Faculty Rank Distribution," Stanford University, 1972.

Hoeneck, S.,"Evaluation of Management Techniques," NASPA, Winter Journal, 1975, pp. 195-221.

Hoeneck, S., "Incentives and Resource Allocations in Universities," Journal of Higher Education, January , 1974, pp. 21-37.

Hopkins, D. S., and Armacost, R., "An Academic Productivity and Planning Model for a University Campus," University of California Administrative Studies Project in Higher Education, Report No. 3, 1970.

Huckfeldt, Vaughn, et al., Introduction to SPS, Technical Report 87, National Center for Higher Education Management Systems, Boulder, Colorado, 1977.

Huff, Robert, "An Approach to Differential Funding for Statewide Systems of Post-secondary Educational Institutions," unpublished manuscript, July, 1975.

_____, Overview of the Cost Estimation Model, NCHEMS, May, 1971.

Hufner, Klaus, "Economices of Higher Education and Educational Planning--A Bilbiography," Socio-Economic Planning Sciences, Vol. 2, 1968, pp. 25-101.

Hussain, K. M., "CAMPUS/COLORADO: The Logic of the Model," Office of Institutional Research, University of Colorado, Boulder, November, 1972.

_____, "A Resource Requirements Prediction Model (RRPM.1): Guide for the Project Manager," TR 20, NCHEMS, 1971.

_____, "A Resource Requirements Prediction Model (RRPM.1): An Introduction to the Model," TR 19, NCHEMS, 1971.

"Improving College Teaching: An Annotated Bibliography," Change August, 1976, New Rochelle, New York.

Jagetia, Lal C., "Regression Analysis in Flexible Budgeting," April, 1976, proceedings of the joint meeting of the Operation Research Society and the Institute of Management Science, April, 1976, Philadelphia.

James, E., Resource Allocation and Costs in Higher Education, State University of New York at Stony Brook, November, 1969.

Jedamus, Paul, "Stochastic Marginal Cost Admissions Model," Association of Institutional Research Proceedings, 1970.

Johnson, Frank Peter, "Differential Tuition Determined by Discipline Unit Cost for Higher Education," Dissertation, Colorado State University, Fort Collins, Colorado, 1975.

Johnson, Richard S., and Huff, Robert A., "Information Exchange Procedures Cost Study Implementation Guide," Technical Report 52, NCHEMS, May, 1974.

Johnston, William (ed), Information and Analysis in the Context of Institutional-State Relationships: The Tie that Divides Us, Proceedings of the 1976 National Assembly, National Center for Higher Education Management Systems, Boulder, Colorado, 1976.

Joint Budget Committee, Appropriation Report, 1970-77, Colorado Legislature, Denver, Colorado.

Judy, R., "Systems Analysis for Efficient Resource Allocation in Higher Education: A Report on the Development and Implementation of CAMPUS Techniques," Paper presented to the Conference on Management Information Systems: Their Development and Application to the Administration of Higher Education, Washington, April, 1969.

Judy, Richard W., "System Analysis and University Planning," Socio-Economic Planning Sciences, Vol. 2, NOS 2/3/4, April, 1969.

Judy, R. W., Some Economics of Post-Secondary Education - A Critical Review, Commission on Post-Secondary Education in Ontario, The Queens Printer, Toronto, Canada, 1971.

Kaiser, Harvey H., "Reduction Planning: Managing in an Era of Declining Resources," NACUBO Professional file, vol. 8, no. 7, September, 1976, Washington, D.C.

Keller, John E., "The Quest for Increased Productivity," in Johnston, William (ed.), Information and Analysis in the Context of Institutional-State Relationships: The Tie That Divides Us, National Center for Higher Education Management Systems, Boulder, Colorado, 1976.

Koenig, Herman E., "A Systems Model for Management, Planning, and Resource Allocations in Institutions of Higher Education," Unpublished manuscript, Michigan State University, Final report project C-518, National Science Foundation, 1967.

Koenig, H., Keeney, M., and Zemach, R. A., "A Systems Model for Management, Planning and Resource Allocation in Institutions of Higher Education," Final report, National Science Foundation Project C-518, Michigan State University, 1968.

Kornfield, Leo L., "Advanced Applied Management Information Systems in Higher Education: Three Case Studies," (Minter and Lawrence, eds.), Management Information Systems: Their Development and Use in Administration of Higher Education, ERIC Reproduction Services, ED042427, October, 1969.

Lamm, Richard D., "The Institution's Responsibility to the State," in Information and Analysis in the Context of Institutional-State Relationship: The Tie that Divides Us, Proceedings of the 1976 National Assembly, National Center for Higher Education Management Systems, Boulder, Colorado, 1976.

Lamont, Douglas F., "Multicampus Systems of Higher Education: A New Organizational Strategy for Knowledge Work," in Macro-Marketing, Distributive Processes from a Societal Perspective, Proceedings of the Macro-Marketing Seminar, University of Colorado, Business Research Division, 1976, ed. Charles Slater.

Lamson, Robert D., and Powel, John J., Jr., "An Improved Model for Determining the Input Cost of University Outputs," Socio-Economic Planning Sciences, Vol. 6, 1972, pp. 273-281.

Lee, D. B., "Requiem for Large-Scale Models," AIP Journal, May, 1973, pp. 163-178.

Lee, S. M., and Clayton, E. R., "A Goal Programmin, Model for Academic Resource Allocation," Management Science, Vol. 18, no. 8, April, 1972.

Levine, J., "A New Tool for Educational Administrators," Report to the Commission on the Financing of Higher Educatio', Toronto: University of Toronto Press, 1965.

Little, John D. C., "Models and Managers: The Concept of a Decision Calculus," Management Science, Vol. 16, no. 8, April, 1970, pp. B466-B485.

Lumsden, Keith G., (ed.), Efficiency in Universities: The La Paz Papers, Amsterdam, London and New York: Elsevier Scientific, 1974.

Lyell, Edward H.,"CAMPUS/COLORADO Program Costing Methodology," Unpublished document, Colorado Commission on Higher Education, Denver, December, 1972.

_____, "Formulation of Optimization Routines Utilizing Instructional Cost Data to Rank Academic Programs for Interinstitutional Evaluation," Presented at ORSA/TIMS Joint Meeting in San Juan, Puerto Rico, October, 1974.

_____, "Higher Education Modeling of the State and National Levels," Assessing Computer Based Systems Models (Tom Mason, Ed.), Jossey-Basse, 1976.

_____, and Busby, John, "What Are the Effects Upon Inter-Institutional Resources Allocation When Institutional Planning and Management Systems are Available?" Presentation at Association of Interinstitutional Research, 14th National Forum, Washington, D.C., May, 1974.

_____, and Gamso, G., "Colorado Information Exchange Procedures Manual," Colorado Commission on Higher Education, Denver, 1975.

_____, Lawrence, Benjamin, and Lovell, Clifton, "The Implications for Educational Research of Emerging Planning and Management Systems in Higher Education," Journal of Educational Research, March, 1971, pp. 291-297.

_____, and Toole, Patrick, "Student Flow Modeling and Enrollment Forecasting," Planning for Higher Education, Vol. 3, no. 6: 2/6, December, 1974.

_____, and Martin, J. N., "A Resource Requirements Prediction Model (RRPM.1): Report on Pilot Studies," TR 21, NCHEMS, 1971.

McNamara, J. R., "Mathematical Programming Applications in Educational Planning," Socio-Economic Planning Sciences, 7, 1973, pp. 19-36.

McNamara, James F., "Mathematical Programming Models in Educational Planning," Review of Educational Research, Vol. 41, no. 5, December, 1971.

Meeth, Richard L., Quality Education for Less Money, Jossey-Bass, San Francisco, California, 1975.

Meisel, William S., Computer-Oriented Approaches to Pattern Recognition, Academic Press, 1972.

Minnesota Higher Education Coordinating Commission, "Making the Transition," Supplement 2 Budget Review Report, February, 1975.

Mintzberg, Henry, "The Manager's Job: Folklore and Fact," Harvard Business Review, July/August, 1975, pp. 49-61.

Moore, Michael A., "Defining and Planning for the Steady State," Educational Board LVI (Spring 1975) pp. 100-110.

Morishima, M., Murata, Y., Nosse, T., and Saito, M., The Working of Econometric Models, New York and London: Cambridge University Press, 1972.

Morrison, Clarence Clapp, "Marginal Cost Pricing and the General Theory of Second Best," Dissertation, University of North Carolina, 1964.

Mowbray, Geroge, and Levine, Jack, "The Development and Implementation of CAMPUS: A Computer-Based Planning and Budgeting System for Universities and Colleges," Educational Technology, 1971.

NACUBO, "Fundamental Consideration for Determining Cost Information in Higher Education," Washington, D.C., 1975.

Nasamura, Masao, "On a Class of Stochastic Optimization Problems with Specified Growth Pattern," Management Science, Vol. 20, no. 2, October, 1973.

National Commission on the Financing of Postsecondary Education. A Proposal: Interim National Standard Procedures for Deriving Per-Student Cost in Postsecondary Educational Institutions. Staff paper, United States Government Printing Office, December, 1973.

National Committee on Standard Reports for Institutes of Higher Education, A Study of Methods Used in Unit-Cost Studies in Unit-Cost Studies in Higher Education, Bulletin, No. 3, Chicago, Illinois: University of Chicago Press, 1932.

Organization for Economic Co-operation and Development, Education and Development Technical Reports, "Costs and Potential Economies; Studies in Institutional Management in Higher Education," 1972.

_____, "Efficiency in Resource Utilization in Education," 1969; Budgeting Programme Analysis and Cost-Effectiveness in Educational Planning," 1968; "Mathematical Models in Educational Planning," 1967.

_____, "The Use of Simulation Models in Educational Planning: A Critical Evaluation of S.O.M.," Paris: O.E.C.D., 1971.

_____, "Simulation and Rational Resource Allocation in Universities," Efficiency in Resource Utilization in Education, Paris: OECD, 1969.

Olson, Mancur Jr., The Logic of Collective Action, Harvard University Press, Boston, Mass., 1965.

O'Neill, June, Resource Use in Higher Education: Trends in Output and Inputs, 1930-1967, Carnegie Foundation for the Advancement of Teaching, 1971, 109 pp.

Philp, H., and Johnstone, J. N., "The Use of Mathematical Models as an Aid to Effective Planning in Education," Planning for Effective Education, Carlton: Australian College of Education, 1971.

Plourde, Paul J., "Models in Higher Education Administration: Is There Hope or Just Continuing Frustration?" Association of Institutional Research, July, 1975.

Plourde, Paul J., "Planning and Management Systems in Higher Education," Amherst College, February, 1974.

Radner, Roy, "A Behavioral Model of Cost Reduction," Bell Journal of Economics, Spring 1975, Vol. 6, no. 1, pp. 196-216.

_____, and Miller, Leonard S., Demand and Supply in U.S. Higher Education, Carnegie Commission on Higher Education, McGraw-Hill Book Company, New York, 1975.

Rath, G. J., "Management Science in University Operation," Management Science, 1968, 14, pp. B373-384.

Reducing the Scope of the University of Wisconsin System, "Report of the System Advisory Planning Task Force University of Wisconsin System Office," Madison Wisconsin, 1975.

Research Reporter, "Higher Education Work Group Offers Paperwork Reforms to Federal Task Forces," NACUBO, November 1976, pp. 11-12, National Association College and University Business Officers, Washington, D.C.

Rhody, Don, et al., An Input-Output Analysis of Colorado, 1975, Colorado State University.

Rodekehr, Mark, The Decline of School Districts in Colorado, Dissertation, 1975, University of Colorado, Boulder, Colorado, 1975.

Schroeder, Roger G., "Four Approaches for the Use of Management Science in University and College Administration: A Comparison," Decision Models in Academic Administration, Albert C. Heinlein (Ed.), Kent State University Press, 1974.

Schroeder, Roger G., "Management Information Systems for Colleges and Universities," to appear in Proceedings of Mid-Atlantic AACSB Deans' Conference, October, 1975.

Schroeder, Roger G., "Survey of Management Science in University Operations," Management Science, Vol. 19, no. 8, April, 1973, pp. 895-906. Also reprinted in Alberg Heinlein (Ed.), "Decision Models in Academic Administration," Kent State University Press, 1974.

Schroeder, Roger G., and Adams, Carl, "The Effective Use of Management Sciences in University Administration," Review of Educational Research, Winter, 1973.

Schroeder, Roger G., Adams, Carl, and Kellogg, E., "Decision Making and Information Systems in Colleges: An Exploratory Study," Journal of Higher Education, January-February, 1976.

Schroeder, Roger G., and Rath, Gustave I., "The Role of Mathematical Models in Educational Research," Psychology in the Schools, October, 1965.

Simon, H. A., "Theories of Decision-Making in Economics and Behavioral Science," The American Economic Review, Vol. 49, no. 3, June. 1959, pp. 253-283.

Sission, R., "Can We Model the Educational Process?" Socio-Economic Planning Services, 1969, 2, pp. 109-119.

Smith, George Albert Jr., "Managing Geographically Decentralized Companies," Harvard University Graduate School of Business Administration Division of Research, 1958.

Smith, R. L., "Accommodating Student Demand for Courses by Varying Classroom Size Mix," Operations Research, Vol. 19, no. 4, July-August, 1971.

Speer, Edgar B., "Business-Education: Parallels in Management," NACUBO Professional File, Vol. 8, no. 6, September, 1976, National Association College and University Business Officers.

Spiegelman, Robert G., "A Benefit/Cost Model to Evaluate Educational Programs," Socio-Economic Planning Sciences, Vol. 1, pp. 443-469.

Staats, Elmer B., "Performance Management in Higher Education," NACUBO Professional File, Vol. 8, no. 5, August, 1976. National Association of College and University Business Officers, Washington, D.C.

Starr, Martin K., and Len Greenwood, "Normative Generation of Strategies with Multiple Criteria Evaluation," Proceedings of the ORSA-TIMS meeting, April, 1976, Philadelphia, Pa.

Stewart, T. R., and J. E. Carter, "POLICY: An Interactive Computer Program for Externalizing, Executing, and Refining Judgmental Policy," Mimeo, Institute of Behavioral Science, University of Colorado-Boulder, Program of Research on Human Judgement and Social Interaction, Report no. 159, 1973.

Stigler, George J., The Theory of Price, Macmillan Co., New York, 1946.

Swart, William W., "A Course Scheduling Problem: Model Development, Analysis and Solution Algorithm," West Virginia University (Presentation to 41st National Meeting of ORSA), April 26, 1972.

Systems Research Group (SRG), "The State of the Art in Educational Cost Modeling Systems," Toronto, November, 1972.

Thompson, Fred, "Information Systems, State-Level Decision Making and the Budget." Mimeo California Post-Secondary Education Commission, 1976.

Thompson, R. K., "Higher Education Administration: An Operating System Study Utilizing a Dynamic Simulation Model," in Corporate Simulation Models (Ed. Schrieber), University of Washington, 1970.

Toole, Patrick, "Use of Data Retrieval Systems in Manpower Planning," University of Colorado, Boulder, March 1976, unpublished mimeo.

Topping, James R., Cost Analysis Manual, Technical Report 45, Boulder, Colorado: National Center for Higher Education Management Systems at the Western Interstate Commission for Higher Education, 1974.

Trivett, David, "Small College Management: Key to Survival," Research Currents, American Association of Higher Education, March, 1973, Washington, D.C.

Turksen, Ismail B., and Holzman, Albert B., "Micro Level Resource Allocation Models for Universities," 37th ORSA Meeting, Washington, 1970.

University of Colorado, Budget Request Documents, 1963-77-78.

_____, Fact Book, 1976, University of Colorado, Boulder.

Urban, G. L., "Building Models for Decision Makers," Interfaces, Vol. 4, no. 3, May, 1974, pp. 1-11.

Van Wijk, Alfons P., Judy, R. W., and Levine, J. B., "The Planning, Programming, Budgeting System in Universities: A Study of Its Applicability and Some Preliminary Designs," Document No. 24, the Institute of Policy Analysis, University of Toronto, October, 1969.

Van Wijk, A. P., Russell, R. S., and Atcheson, R. M., "The Use of Simulation Models in Educational Planning," Systems Research Group, June, 1971.

Wallhaus, Robert A., Measuring Increase in Academic Productivity, Jossey-Bass Inc., San Francisco, 1975.

Wartgow, Jerome F., "Computer Simulation: Panacea or Headache?" Planning for Higher Education, Journal of the Society for College and University Planning, Volume 1, Number 1/4, 1972.

Wartgow, Jerome F., "Computerized Institutional Planning Models: An Objective Analysis," North Central Association Quarterly, Vol. 28, no. 3, Winter, 1973, pp. 326-331.

Wartgow, Jerome F., (contributor) "Let's End the Confusion About Cost Simulation Models!" (Millett, Ed.) Washington, D.C., Academy for Educational Development, 1973.

Wartgow, Jerome F., "Simulating the University: An Evaluation of Experiences with the CAMPUS, HELP/PLANTRAN and SEARCH Systems," Tomorrow's Imperatives Today (Cope, Ed.), Tallahassee, Florida: Association for Institutional Research, 1973.

Wartgow, Jerome F., "Implementing a Distributive Cost Matrix," Reformation and Reallocation in Higher Education (Ed. Stewart), Claremont, California: Association for Institutional Research, Claremont University Center, 1972, pp. 30-34.

Wartgow, Jerome F., Forsythe, Ralph, and Roesler, Elmo, "Proposal for Implementation of a Planning-Programming-Budgeting System at the University of Denver," Denver, Colorado: Bureau of Educational Research, University of Denver, 1972.

Weathersby, G. B., The Development and Application of a University Cost Simulation Model, Graduate School of Business Administration and Office of Analytical Studies, University of California, 1967.

Weathersby, G. B., and Weinstein, M. C., "A Structural Comparison of Analytical Models for University Planning," Ford Research Program in University Administration, University of California, Berkeley, August, 1970.

Wing, Paul, "An Empirical Analysis of Factors Related to Expenditures in Higher Education Institutions," Western States Project on Postsecondary Education Budgeting Procedures, 1976, draft. Western Interstate Commission on Higher Education, Boulder, Colorado, 1976.

Wish, John R., "The Great Marketing Game: Theory and Practice Applied to Post Secondary Education," in Macro-Marketing, Distributive Processes from a Societal Perspective, Proceedings of the Macro-Marketing Seminar, University of Colorado, Business Research Division, 1976, ed. Charles Slater.

Witmer, David R., "Cost Studies in Higher Education," Review of Educational Research, Vol. 42, no. 1, Winter, 1972.

Zale, David, "Representative Government: Is It Truly Representative? The Colorado State Budgeting Process, A Case Study," unpublished, University of Colorado, May, 1976.

Ziermer, Gordon, Young, Michael, and Topping, James, Cost Finding Procedures, Technical Report 26, Boulder, Colorado: National Center for Higher Education Management Systems at the Western Interstate Commission for Higher Education, November, 1971.